



(12) **United States Patent**
Uscinski et al.

(10) **Patent No.:** **US 10,671,160 B2**
(45) **Date of Patent:** **Jun. 2, 2020**

(54) **EYE TRACKING CALIBRATION TECHNIQUES**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/993,371**

(22) Filed: **May 30, 2018**

(65) **Prior Publication Data**

US 2018/0348861 A1 Dec. 6, 2018

Related U.S. Application Data

(60) Provisional application No. 62/512,954, filed on May 31, 2017.

(51) **Int. Cl.**

G06F 3/01 (2006.01)
G06T 19/00 (2011.01)
G06T 7/70 (2017.01)
G06T 15/06 (2011.01)
A63F 13/213 (2014.01)
A63F 13/211 (2014.01)
A63F 13/22 (2014.01)
A63F 13/212 (2014.01)

(Continued)

(52) **U.S. Cl.**

CPC **G06F 3/013** (2013.01); **A63F 13/211** (2014.09); **A63F 13/212** (2014.09); **A63F 13/213** (2014.09); **A63F 13/22** (2014.09); **G06F 1/163** (2013.01); **G06F 3/011** (2013.01); **G06F 3/012** (2013.01); **G06F 3/016**

(2013.01); **G06K 9/00** (2013.01); **G06K 9/00604** (2013.01); **G06K 9/00671** (2013.01); **G06T 7/70** (2017.01); **G06T 15/06** (2013.01); **G06T 19/006** (2013.01); **A63F 2300/8082** (2013.01)

(58) **Field of Classification Search**

CPC **G06F 3/011–013**; **G02B 2027/0198**
USPC **345/7–8**; **351/208–209**
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,850,221 B1 2/2005 Tickle
D514,570 S 2/2006 Ohta

(Continued)

FOREIGN PATENT DOCUMENTS

WO WO 2018/222753 12/2018

OTHER PUBLICATIONS

International Search Report and Written Opinion, re PCT Application No. PCT/US2018/035190, dated Aug. 8, 2018.

(Continued)

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(57) **ABSTRACT**

Systems and methods for eye tracking calibration in a wearable system are described. The wearable system can present three-dimensional (3D) virtual content and allow a user to interact with the 3D virtual content using eye gaze. During an eye tracking calibration, the wearable system can validate that a user is indeed looking at a calibration target while the eye tracking data is acquired. The validation may be performed based on data associated with the user's head pose and vestibulo-ocular reflex.

33 Claims, 24 Drawing Sheets

